

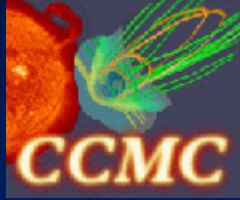


# Solar and Heliospheric Models at the Community Coordinated Modeling Center

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NASA GSFC

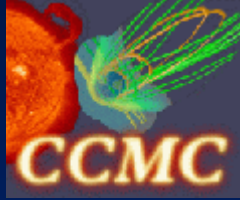




# What is CCMC?

Multi-agency activity to

- Aid in the development of space weather prediction models
- Bridge the transition from research to operations
- Provide access to state-of-the-art research models to the scientific community



# CCMC Activities

- Model Validation
- Metric Studies
- Advanced Visualization Tools
- Execute Runs on Request
- Transfer Models to the Operational Community
- Perform Data Format Studies

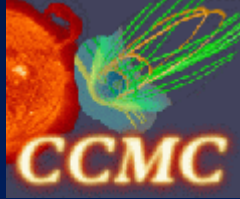


# Solar and Heliosphere Models

- **MAS Solar Corona** (*J. Linker, Z. Mikic et al., SAIC*)
- **Source Surface Model** (*J. Luhmann et al., UCB*)
- **Heliospheric Tomography** (*B. Jackson et al., CASS/UCSD*)
- **Exospheric Solar Wind** (*Lamy, Pierrat, IASB, Belgium*)
- **Heliospheric MHD Model** (*D. Odstrcil*)



# Runs on Request



## The Community Coordinated Modeling Center

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### Step 1: Fill in the Form and Generate a Registration Number for each Requested Run.

The Registration Number is composed of your first name (FirstName), your last name (LastName), date (mmddyy), model type (GM - Global Magnetosphere, IT - Ionosphere/Thermosphere, SH - Solar/Heliosphere), and run identification number (RunNumber):

FirstName\_LastName\_mmddyy\_ModelType\_RunNumber, e.g., George\_Siscoe\_060601\_SH\_1.

At the present time you are allowed to make up to 4 different submissions on the the same date (mmddyy) for each model type. For each new submission made on the same date for the same model type you need to choose a new Run Number ("1", "2", "3", or "4"). Multiple submissions made on the same date with the same Run Number and Model Type will overwrite the previous submission. You can use this feature to resubmit the request on the same date. If you decide to cancel or modify your submission at later date, please contact the CCMC staff:

e-mail: [requests@ccmc.gsfc.nasa.gov](mailto:requests@ccmc.gsfc.nasa.gov)

tel: Masha Kuznetsova (301-286-9571), Lutz Rastaetter (301-286-1085).

Please have registration numbers when making inquiries about your requests. You will need your registration number to view the results when the simulations have finished.

First Name:  (required)

Last Name:  (required)

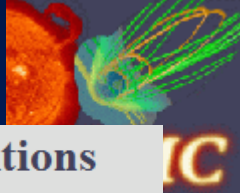
Address:

Telephone:  (required)

E-mail:  (required)

Run Number:

# Runs on Request



## Step 3: Set The Simulation Time Interval

Choose Carrington rotation or date of interest

Select:

☒ Carrington rotation number between 1625 and 2007:

or

☐ Date (MM/DD/YYYY) between 02/18/1975 and 08/29/2003  /  /

Selection of Carrington rotation numbers and dates is subject to change.

### Specify the duration of the run

hours

Maximum duration of the run is 80 hours of real time.

Minimum duration of the run is 5 hours of real time.

## Step 4: Set The Simulation Grid

Select grid resolution (NRxNTxNP) from predefined list:

## Step 5: Set The Boundary Conditions

Confirm selection of Carrington Rotation based on available data

Rotation: 2007 Start: 08/29/2003 End: 09/26/2003

### Select coronal base temperature and density

Coronal base temperature:  x 10<sup>6</sup> [K]

Coronal base density:  x 10<sup>8</sup> [particles cm<sup>-3</sup>]  
(density range: (1.0 - 4.0) x 10<sup>8</sup> [particles cm<sup>-3</sup>])

### Select filter parameters for magnetogram data

Selected simulation grid: medium resolution (85x81x64)

Recommended maximum longitudinal mode number: 8

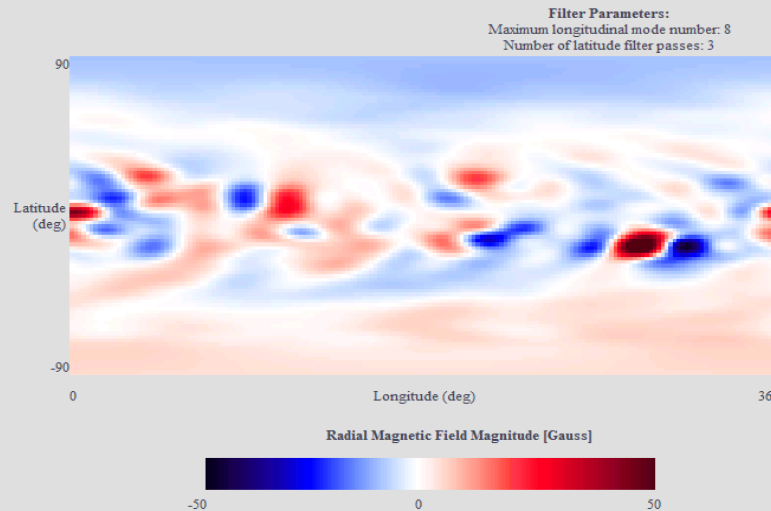
Recommended number of latitude filter passes: 3

Recommendations and ranges for filter parameters are based on grid resolution.

Maximum longitudinal mode number (Range: 1 - 9)

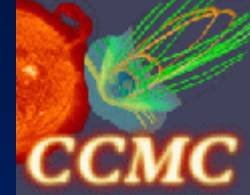
Number of latitude filter passes (at least 2):


## Filtered Kitt Peak Magnetogram





# Visualization Tool





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### 3D Simulation Results: Model: MAS

Run: Kristi\_Keller\_011204\_SH\_1 CR=1901, T=1.6 K, N=2e8/cm<sup>3</sup>

This is the web interface for the visualization of results of a three-dimensional simulation of the Sun's environment.

Please review the [default selections](#) below and make your changes.

To start the graphics program click the *Update Plot* button. The resulting image will be displayed at this location of the page.

Should the result be a black image, then the graphics program encountered a programming error. Please report the set of input parameters used.

Update Plot *Update Plot* will update (generate) the plot with the chosen time and plot parameters below. This will take some time (typically 10-30s) as data is read in and processed.

**Plot Options:**

☒ Choose data time:  
24:00:14   
- or -  
☐ Change time by moving  
 output steps

☒ Exclude region around the Sun up to  R<sub>s</sub>  
☒ Allow variable plot image size (2D plots, aspect ratio (ratio dx/dy of plot) between 0.3 and 4)  
☐ Show simulation grid (disabled with 3D-Surface)  
☐ Interpolate data onto equidistant grid  
(available with 3D-Surface and Vector recommended for plots with Vector)

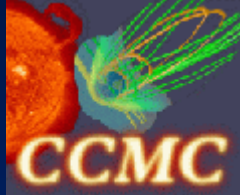
Choose [Plot Mode](#):   Choose [quantity](#) to be displayed (some Plot Modes require up to three choices)  
Q 1:   Q 2:   Q 3:


**Plot Options for selected Plot Modes:**

3D-Surface, 3D-Flowlines View angles:  
AX [-90..90]:  AZ [ 0..180]:   
Color Contour: ☐ Use Grayscale

3D-Flowlines: flowline start positions  
Choose [Flowline Setup Mode](#):

# Visualization Tool





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**Plot Options** 3D-Surface, 3D-Flowlines View angles:  
for selected AX [-90..90]:  AZ [ 0..180]:   
**Plot Modes:** Color Contour: ☐ Use Grayscale  
☐ Lock color range: (Log scale: use original values > 0)  
Min.:  Max.:   
☐ Log scale (N/Rho, En. P, most fluxes F...)  
**Contour:** ☐ show values with contour levels  
**Vector:** length of arrows:

**3D-Flowlines:** flowline start positions  
Choose [Flowline Setup Mode](#):  
  
user-defined flowline start positions:  
Radius r:   
Lon. p:   
Lat. t:

**Choose Plot Area:**  
All Plot Modes except Line Plot: Select lower left corner of plot area on the left, and the upper right corner on the right.  
Line Plot: Select start point of line on the left, the end point on the right.

Radius  $r_1$   Radius  $r_2$   Range: 1 ... 30  $R_S$   
Lon.  $p_1$   Lon.  $p_2$   Range: 0 ... 360 deg.  
Lat.  $t_1$   Lat.  $t_2$   Range: -90 ... 90 deg.

**Choose Cut Plane:**  
Radius r=constant ☐   
Lon. p=constant ☒   
Lat. t=constant ☐

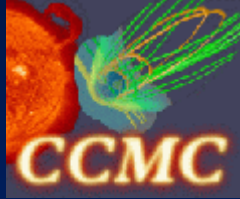
*Reset Form will reset changes to the defaults specified by the previous run of this script.*

*Update Plot will update (generate) the plot with the chosen time and plot parameters above.*

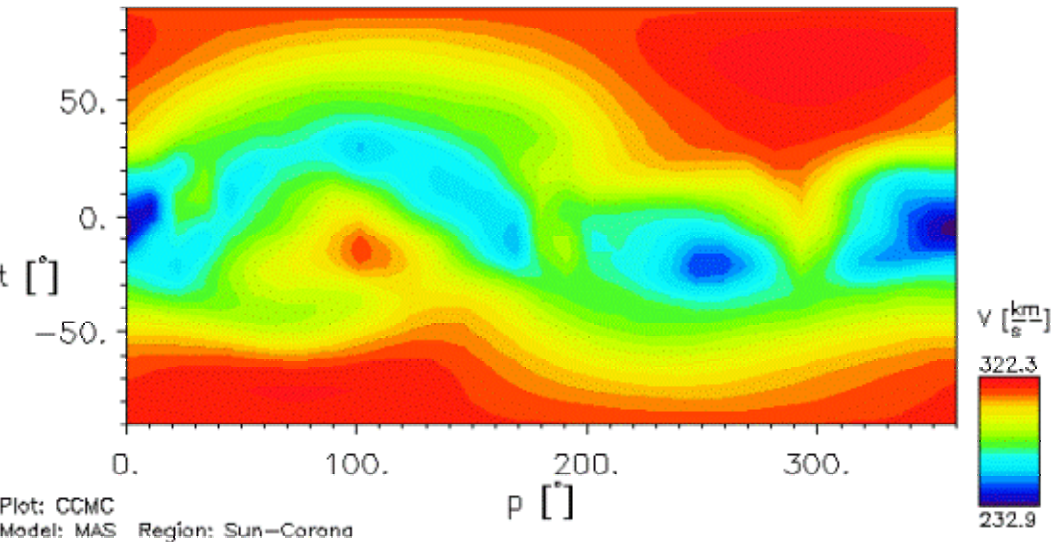
☐ **List Data** (check to get any of the following outputs):  
☐ At positions specified: enter positions in Radius r, Lon. p, Lat. t, (within the allowed range) as comma-separated lists.  
Radius r positions:   
Lon. p positions:



# Examples of Output



Time = 1:16:00:28  $r = 20.0R_s$



Color Contour Plots

Vector Plots

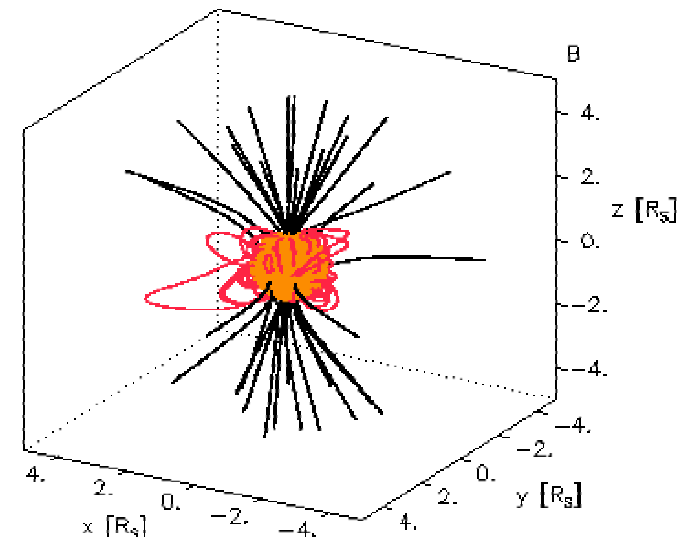
Fieldlines

Line Plots

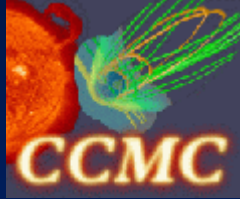
Time = 1:16:00:28

Fieldlines:

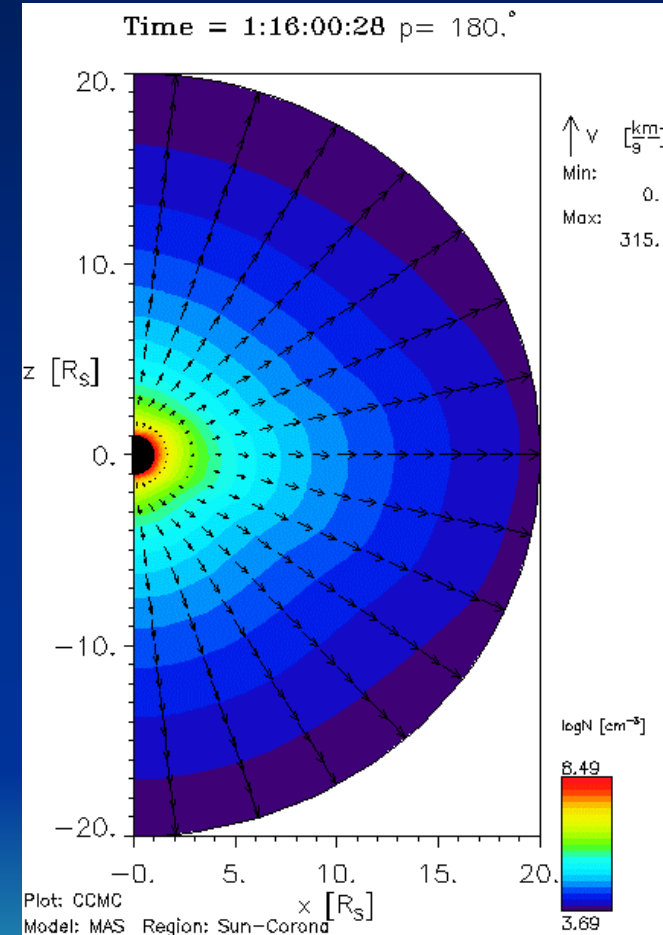
— coronal hole  
— closed  
— user selected



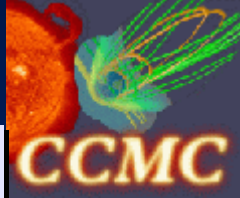
# Solar MAS



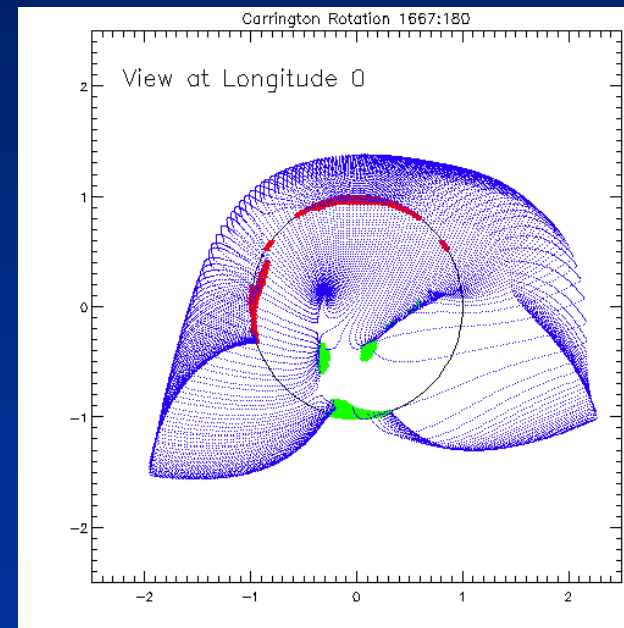
- MHD equations
- Photospheric magnetic field data is used for the boundary condition on  $B_r$ .
- Solved to steady state
- Input at Photosphere
  - Magnetic field (CCMC web site user enters date)
  - Density
  - Temperature
- Output
  - Magnetic field
  - Velocity
  - Density
  - Temperature



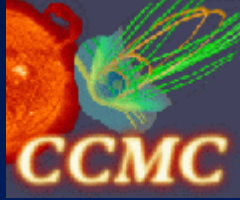
# Potential Source Surface Model



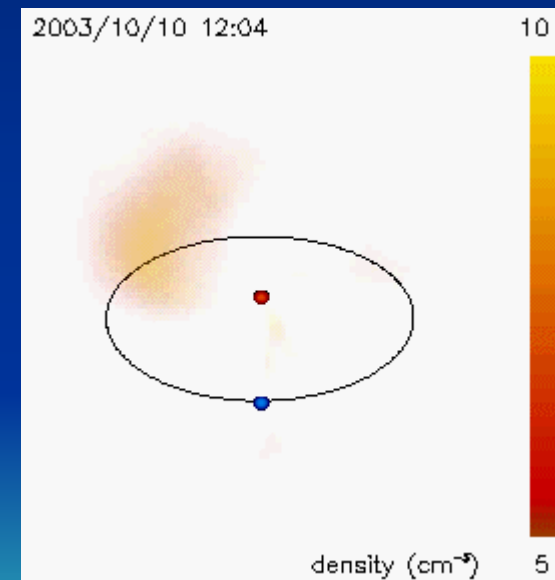
- The model calculates the magnetic field of the corona from the radius of the sun to the source surface radius assuming that there are no currents in this region.
- The code uses spherical harmonic coefficients calculated by Wilcox Solar Observatory using observed photospheric fields (magnetograms) as input.
- User input:
  - Date
  - Source Surface Radius ( $1.6 - 3.25 R_s$ )
  - Number of spherical harmonic coefficients
- Output – Magnetic Field Mappings



# Heliospheric Tomography

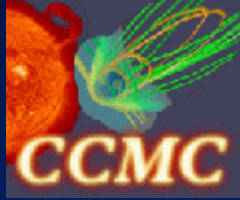


- Kinematic model using conservation rules
- Density and velocity specified on source surface
- Using kinematic model, IPS velocity and g-level data are calculated by the model and compared with observations. Using an iterative least-squares algorithm, the source surface is updated to obtain the best model for the solar wind.
- Input for CCMC web site user: Date
- Output
  - Radial Velocity
  - Density

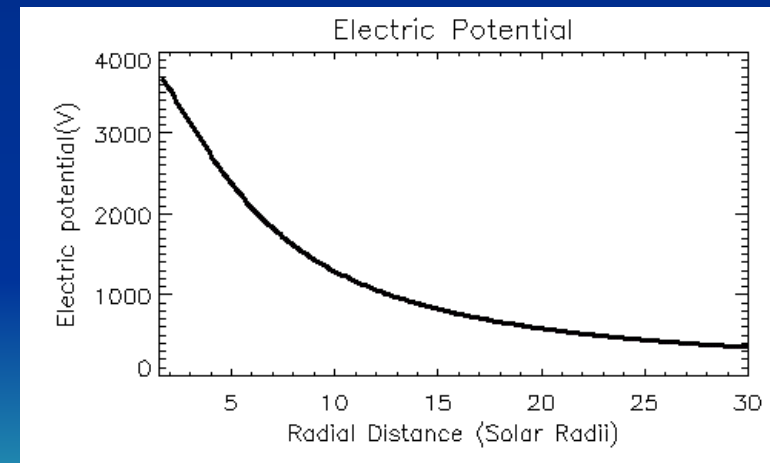
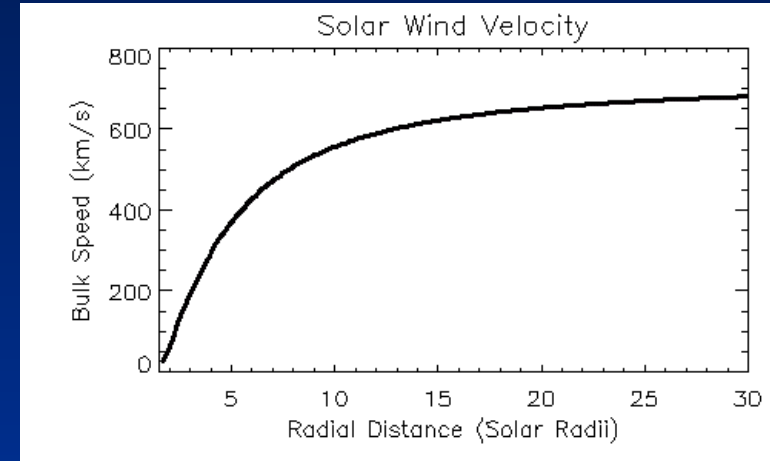




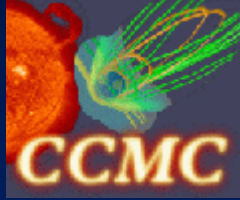
# Exospheric Solar Wind Model



- One-dimensional kinetic model developed for coronal holes
- Uses quasi-neutrality to obtain a radial distribution of the electrostatic potential.
- Calculates the moments of the electron and proton velocity distribution function (VDF) using the electrostatic potential
- Input
  - Radial distance of exobase
  - Temperature of the electrons and protons at the exobase
  - Kappa index for electrons VDF
  - Radial distance of end point
- Output
  - Density
  - Flux of particles
  - Bulk velocity of solar wind
  - Temperature of electrons and protons
  - Electric potential

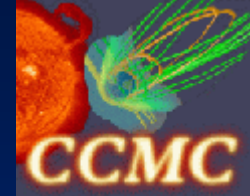


# Odstrcil Heliosphere Model



- MHD equations solved from 20 to 220  $R_s$
- Input at inner boundary
  - MHD parameters
- Output
  - Magnetic field
  - Velocity
  - Density
  - Temperature

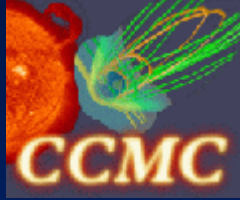
# Model Selection at the CCMC



Models are selected by the Steering Committee using the following guidelines:

- Relevance to the research and operational goals of the National Space Weather Program
- Compatibility with existing resources at CCMC
- Reliability
- Documentation





# Heliospheric Tomography

Velocity

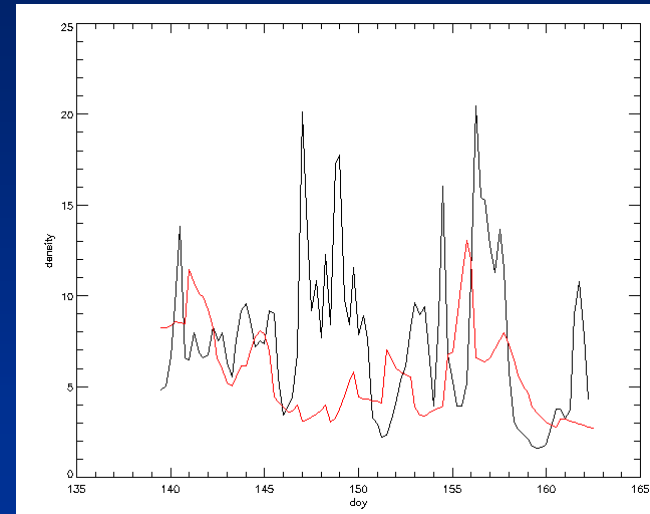
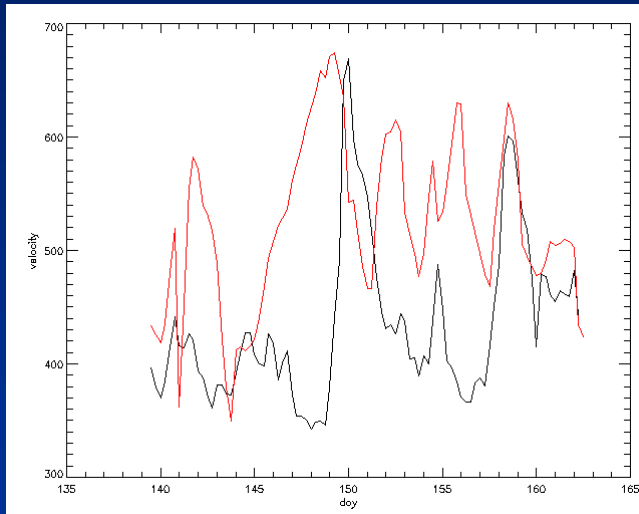
Density

700

20

Interval 1

300



800

40

Interval 2

300

